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Peter L. Holmes

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Assistant Commissioner For Patents
BOX Patent Application
Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the new patent application of:

Inventor(s): Zafar Iqbal, Dave Narasimhan, James V. Guiheen and Timothy Rehg

Title: Corrosion Resistant Coated Fuel Cell Plate With Graphite Protective Barrier And Method Of Making The Same

Enclosed are:

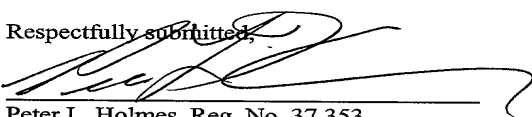
- ☒ Specification, claims and abstract, totaling 17 pages.
- ☒ 3 Sheets of Drawings X Informal Formal (Figs. 1-6C)
- ☒ Declaration and Power of Attorney
- ☒ Assignment of the invention to AlliedSignal, Inc., P.O. Box 1219, 101 Columbia Road, Morristown, New Jersey 07962, including an Assignment Cover sheet
- ☒ A Post Card Receipt
- ☐ A Verified Statement Claiming Small Entity Status
- ☒ General Authorization/Request to Petition for Extension of Time
- ☒ Information Disclosure Statement, Form PTO 1449 and the cited references

The filing fee has been calculated as shown below:

FOR:	CLAIMS FILED	NO. EXTRA	SMALL ENTITY RATE	SMALL ENTITY FEE	STANDARD RATE	STANDARD FEE
BASIC FEE				\$380		\$760
TOTAL CLAIMS	20 minus 20 =	0	X \$9	\$	X \$18 =	\$
INDEPENDENT CLAIMS	3 minus 3 =	0	X \$39	\$	X \$78 =	\$
MULTIPLE DEPENDENT CLAIMS PRESENTED			X \$130 =		X \$260 =	
			TOTAL \$	\$	TOTAL	\$760

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 - ☐ The issue fee set in 37 C.F.R. 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Respectfully submitted,


Peter L. Holmes, Reg. No. 37,353
AlliedSignal, Inc.
Law Dept., M/S 36-2-76000
2525 West 190th Street
Torrance, California 90504-6099

Oct. 8, 1999
Date

**CORROSION RESISTANT COATED FUEL CELL BIPOLAR PLATE
WITH GRAPHITE PROTECTIVE BARRIER
AND METHOD OF MAKING THE SAME**

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to U.S. patent application serial number _____ entitled "Corrosion Resistant Coated Fuel Cell Bipolar Plate With Filled-In Fine Scale Porosities and Method of Making the Same" filed herewith.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

This invention was made with support from the government of the United States of America. The government of the United States of America may have certain rights in this invention.

BACKGROUND OF THE INVENTION

1. Field of Invention

The present invention relates generally to a corrosion resistant coated fuel cell bipolar plate and a method for making the same and, more specifically, to a corrosion resistant coated fuel cell bipolar plate with a graphite protective barrier and a method of making the same.

2. Description of the Related Art

Fuel cells such as the Proton Exchange Membrane ("PEM") fuel cell include a membrane electrode assembly ("MEA"). The MEA comprises a solid polymer electrolyte or ion exchange membrane positioned between an anode and a cathode which typically comprise finely divided carbon particles, very finely divided catalytic particles supported on the internal and external surfaces of the

carbon particles, and proton conductive material intermingled with the catalytic and carbon particles.

The catalytic particles, e.g., finely comminuted platinum, at each membrane/electrode interface induce the desired electrochemical reaction. On the anode side, the fuel (e.g., hydrogen) permeates the porous electrode material and reacts with the catalytic particles to form hydrogen cations (e.g., protons) which migrate through the ion exchange membrane to the cathode side. On the cathode side, the oxidant (e.g., oxygen-containing gas) reacts with the catalytic particles to form oxygen anions. At the cathode, the anions react with the cations to complete the electrochemical reaction and form a reaction product (e.g., liquid water).

In conventional fuel cells, the MEA is positioned between a pair of electrically conductive elements, typically plates, which serve as current collectors for the anode and cathode. The plates are often formed with channels to facilitate the distribution of the aforementioned gaseous reactants over the anode and cathode catalyst surfaces. When a plurality of fuel cells are configured as a stack to form a series electrical connection between them, the plates provide the electrical connection and are often referred to as bipolar plates. In such a configuration, each bipolar plate conducts current between the anode of one cell to the cathode of the adjacent cell in the stack.

In the PEM fuel cell environment, bipolar plates (and septums) are subject to corrosion. Therefore, in addition to having sufficient electrical conductivity to provide high performance in a PEM fuel cell, bipolar plates should also be corrosion-resistant so as to maintain adequate conductivity over extended periods of time. Graphite plates exhibit these qualities, but are

generally, brittle and expensive to manufacture. Noble metals such as platinum are highly corrosion-resistant and manufacturable as lightweight thin plates, but the raw material costs for these plates would be prohibitive for many commercial applications. Lightweight metals such as aluminum and titanium and their alloys are not corrosion resistant in the PEM fuel cell environment, and contact elements made therefrom typically deteriorate rapidly, or they form highly electrically resistant oxide films on their surface that increase the internal electrical resistance of the fuel cell and reduce its performance.

Thus, a need exists for a fuel cell bipolar plate made from a non-noble, lightweight metal such as aluminum or titanium with surfaces that are protected against corrosion by an electrically conductive, oxidation-resistant barrier, coating or cladding.

SUMMARY OF THE INVENTION

In an exemplary preferred embodiment, a metal fuel cell bipolar plate is provided with a conductive multilayer coating and then with an overcoating which fills in the fine scale porosities in the underlying coating. The dimensions of the coating and the overcoating are selected so that the electrical conductivity of the bipolar plate is not compromised. The overcoating provides sealing of fine scale porosities and can be continuous if it has inherent conductivity, for example, an overcoating formed from a slurry of amorphous carbon or a suboxide of titanium. In the case of amorphous carbon, this overcoating is also hydrophobic which further prevents corrosive electrolytes from penetrating microporosities in the coating.

5 In another exemplary preferred embodiment, a metal fuel cell bipolar plate is provided with a conductive multilayer coating and then a chemical anodization process is employed to fill in the fine scale porosities in the underlying coating with a discontinuous overcoating which may not have high electrical conductivity, for example, an aluminum oxide, but which guides electrical charge to the coating through discontinuities in the overcoating. The filling in of the porosities prevents corrosive electrolytes from attacking the coated fuel cell bipolar plate.

10 In another exemplary preferred embodiment, a metal fuel cell bipolar plate is provided with a thin, graphite emulsion coating and then a layer of graphite foil is pressed over the underlying coating. The emulsion of graphite seals in microporosities present in the graphite foil. Additionally, the hydrophobic nature of the graphite emulsion coating and the graphite foil helps prevent corrosive electrolytes from attacking the coated fuel cell bipolar plate.

20 The above described and many other features and attendant advantages of the present invention will become apparent as the invention becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

30 Detailed description of preferred embodiments of the invention will be made with reference to the accompanying drawings.

FIG. 1 is a flowchart of two exemplary preferred methods for coating and overcoating a bipolar plate of a fuel cell according to the present invention;

FIG. 2 is a flowchart of another exemplary preferred method for coating and overcoating a bipolar plate of a fuel cell according to the present invention;

5 FIG. 3 is a cross-sectional, partial side view of a fuel cell bipolar plate;

FIG. 4A is an enlarged view of a portion of the fuel cell bipolar plate of FIG. 3 after it has been coated with a sub-layer of transition metal such as titanium;

10 FIG. 4B shows the fuel cell bipolar plate of FIG. 4A after it has been coated with a layer of titanium aluminum nitride;

FIG. 4C shows the fuel cell bipolar plate of FIG. 4B after it has been overcoated with a sub-layer of transition metal such as chromium;

15 FIG. 4D shows the fuel cell bipolar plate of FIG. 4C after it has been overcoated with a layer of amorphous graphite;

20 FIG. 4E shows the fuel cell bipolar plate of FIG. 4B after it has been subjected to a chemical anodization process to form a thin, discontinuous top layer composed of an oxide such as aluminum oxide which serves to fill in porosities in the coating;

FIG. 5 is a cross-sectional, partial side view of a fuel cell bipolar plate;

25 FIG. 6A is an enlarged view of a portion of the fuel cell bipolar plate of FIG. 5 after it has been coated with a layer of graphite emulsion;

30 FIG. 6B shows the fuel cell bipolar plate of FIG. 6A after a sheet of graphite foil has been pressed over the layer of graphite emulsion which bonds the graphite foil to the bipolar plate and seals porosities in the graphite foil; and

FIG. 6C shows the fuel cell bipolar plate of FIG. 6B after a flow field has been stamped in it deforming both the graphite foil and the underlying metal plate.

5 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

10 The following is a detailed description of the best presently known mode of carrying out the invention. This description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention.

15 Referring to FIG. 1, an exemplary preferred method 100 according to the present invention for passivating a bipolar plate for a fuel cell first includes a step 102 of providing a fuel cell bipolar plate 200 (FIG. 3) which can be formed from any metal, noble or non-noble. The fuel cell bipolar plate 200 preferably comprises aluminum, an aluminum alloy or stainless steel, is 0.05-2.0 millimeters thick and has flow fields 202 stamped on both sides (only one side of the bipolar plate 200 is shown in FIG. 3).
20 Alternative preferred materials for the fuel cell bipolar plate 200 include, but are not limited to, titanium, niobium, chromium, tin, molybdenum, zinc, stainless steel and nickel. Furthermore, it should be understood that the principles of the present invention are not limited to
25 bipolar plates and are equally applicable to end plates, current collector elements and electrically conductive elements configured in shapes other than that of a plate.

30 Generally, the method 100 includes a coating step 110 and one of a deposition overcoating step 120 or a chemical anodization overcoating step 130. In an exemplary preferred embodiment, the coating step 110 includes a step 112 of coating a top surface 204 (FIG. 4A) of the bipolar plate 200 with a transition metal sub-layer 206 (FIG. 4A) and then a step 114 of coating the sub-layer 206 with a

layer 208 (FIG. 4B) of conductive material. Both the sub-layer 206 and the layer 208 are electrically conductive. The sub-layer 206 and layer 208 are selected such that the layer 208 will adhere to the sub-layer 206 during sputtering. The sub-layer 206 comprises, for example, titanium sputtered over the top surface 204 to a thickness of approximately 1 micron. The sub-layer 206 can also be formed from other conductive materials, e.g., stainless steel.

An exemplary preferred layer 208 comprises a range of compositions for titanium aluminum nitride (Ti_xAl_yN), where $x = 0.50-0.75$ and $y = 0.25-0.50$. Preferred values for x and y are 0.70 and 0.30, respectively. The titanium aluminum nitride layer 208 is formed, for example, by simultaneously sputtering Ti and Al with a nitrogen bleed. The thickness of the layer 208 is preferably in the range of 1 to 5 microns. The addition of Al to Ti reduces the density of d-electron states and therefore the oxidation stability of the coating layer 208. The electrical conductivity of the layer 208 is also reduced relative to TiN by the addition of Al, but still remains very high at the above composition. Typical resistivities are below 1 milliohm-centimeter. Alternative compositions for the coating 208 include, but are not limited to, titanium nitride, titanium carbide, an alloy of titanium nitride and titanium carbide, which is also referred to as titanium carbonitride, zirconium nitride and chromium nitride.

A physical vapor deposition ("PVD") process is preferably used to deposit the sub-layer 206 and the layer 208. A closed-field, unbalanced magnetron sputter ion plating system (see, e.g., European Patent Specification EP 0 521 045 B1, the entirety of which is incorporated

herein by reference) is preferably employed during the entire coating step 110. In such a system, unbalanced magnetrons are employed in an arrangement whereby neighboring magnetrons are of opposite magnetic polarity.

5 Linked magnetic field lines surround the deposition zone where the substrates are located. This results in significant plasma enhancement due to trapping of the plasma and prevention of ionizing electron losses. The two main features of such a system are that: (1) high
10 current density is used to improve both the coating structure and adhesion, and (2) low bias operation is used to deposit coatings at low temperatures and with minimal internal stresses.

Significantly, the low bias (near-zero), low
15 temperature operation causes the crystalline particles of the coating 208 to be smaller in size and more rounded which provides improved meshing of grain boundaries. This, in turn, results in smaller porosities in the coating 208.

20 After the bipolar plate 200 has been stamped or machined with flow field patterns, gas inlets, etc., it is degreased, dried and reductively plasma-etched in the reactor. Cleaning prior to deposition is carried out with the magnetrons switched on at low power. The use of
25 magnetrons at this stage allows a plasma to strike to the plates at low argon pressure of approximately 1×10^{-3} Torr.

After an initial pump down to a pressure of 10^{-6} Torr, the sub-layer 206 and the layer 208 are formed on the
30 plate 200 which is held at room temperature in the deposition chamber. During the deposition process, the temperature of the plate rises to between 200°C and 350°C due to plasma bombardment. Through appropriate shielding and current control in the deposition chamber, multiple

targets can be employed in a conventional fashion to provide the Ti/TiAlN graded coating described above. Although magnetron sputtering is preferred because it provides coatings with low porosity, the scope of the present invention additionally contemplates employing alternative deposition processes such as cathodic arc sputtering and low temperature metal-organic chemical vapor deposition ("MOCVD").

On examination under a scanning electron microscope, the magnetron-sputtered titanium aluminum nitride layer 208 shows no open porosity in the 0.1 to 1.0 micrometer size range. However, potentiodynamic corrosion currents measured at 900 mV versus a saturated calomel electrode suggest that porosities below this range are present. The overcoating steps 120, 130 -- alternative processes for sealing the fine scale porosity in the titanium aluminum nitride coating 208 -- are discussed below.

Referring to FIG. 1, an exemplary preferred deposition overcoating step 120 includes a step 122 of coating the fuel cell bipolar plate 200 (more specifically, the titanium aluminum nitride layer 208) with a transition metal sub-layer 210 (FIG. 4C) and then a step 124 of coating the sub-layer 210 with a hydrophobic amorphous graphite top layer 212 (FIG. 4D). The transition metal sub-layer 210 can be any metal to which graphite/carbon readily adheres. An exemplary preferred sub-layer 210 comprises a 0.5-1.0 micron thick layer of chromium. Other suitable materials for the sub-layer 210 include, but are not limited to, titanium, nickel, iron and cobalt. The hydrophobic amorphous graphite layer 212 is preferably 2-5 microns in thickness.

The transition metal sub-layer 210 and then the amorphous graphite top layer 212 are deposited using the unbalanced magnetron sputtering process described above

with reference to step 110. The same or a different chamber can be used for the overcoating step 120. The bipolar plate 200 to be overcoated is held at room temperature after an initial pump down to 10^{-6} Torr. The amorphous graphite layer 212 is at least partially formed as a continuous, random network structure and is substantially free of grain boundaries other than macroscopic porosities where deposition did not occur. After cooling, the bipolar plate 200 is taken out of the deposition chamber for use in a fuel cell without further treatment.

Referring to FIG. 4D, porosities 214 are shown (not necessarily to scale) in the layer 208. The porosities are coated, but may not be filled in completely, by the transition metal sub-layer 210. The amorphous graphite layer 212 is shown filling in the two porosities 214. It should be appreciated, however, that some porosities (not shown) are too small to be filled in by the amorphous graphite. Notwithstanding, the hydrophobic nature of the amorphous graphite layer 212 -- which coats the perimeter of such porosities even if it does not fill them -- helps to prevent gases and water from oxidizing the bipolar plate 200.

Referring to FIG. 1, an alternative to the deposition overcoating step 120 is the chemical anodization overcoating step 130. In a preferred embodiment, the chemical anodization or oxidation overcoating step 130 seals the fine scale porosities in the layer 208 with a discontinuous low conductivity oxide layer 216 (FIG. 4E) such as aluminum oxide. In the case of aluminum oxide, the chemical anodization process infiltrates the fine scale porosity with internal layers of alumina. The layer 216 is primarily localized on the porosities as an amorphous structure and guides

electrical charge to the layer 208 via discontinuities in the layer 216. Alternatively, the chemical anodization or oxidation overcoating step 130 seals the fine scale porosities in the layer 208 with a continuous (or
5 discontinuous) layer 216 of material, such as a suboxide of titanium, which is sufficiently electrically conductive to permit electrical charge to pass through the layer 216 to the layer 208.

An exemplary preferred chemical anodization
10 overcoating step 130 includes a step 132 of dipping the bipolar plate 200 into an acid bath, a step 134 of washing the bipolar plate 200 in deionized water, and a step 136 of boiling the bipolar plate 138 in water. An exemplary preferred step 132 comprises dipping the coated
15 bipolar plate 200 in concentrated sulfuric acid (95-98% ACS reagent) at ambient temperature for 0.5-1.0 minute. Alternatively, chromic acid can be used. Alternatively, elevated temperatures and surfactants can be used to enhance acid penetration into the porosity 214. Another
20 alternative is to use electrolytic oxidation. Next, at step 134, the bipolar plate 200 is removed from the acid bath, immediately immersed in deionized water and washed until free of acid. At step 136, the overcoating layer 216 is stabilized by boiling in deionized water for
25 approximately 30 minutes. The bipolar plate 200 is then taken out of the water bath and blow-dried in air at room temperature prior to use. On titanium aluminum nitride, oxidation results in the formation of both aluminum and titanium oxides.

30 Referring to FIG. 2, an exemplary preferred method 300 according to the present invention for providing a fuel cell bipolar plate with a corrosion-resistant barrier includes a step 302 of cleaning a plate 400 (FIG. 5), a step 304 of applying a coating 402 (FIG. 6A) to an outer

surface 404 of the plate 400, and a step 306 of providing an overcoating 406 (FIG. 6B). The bipolar plate 400 is the same as the previously described bipolar plate 200 with machined gas inlet holes, but typically is not formed with flow fields before the coating 402 and overcoating 406 are applied. An exemplary preferred bipolar plate 400 is made from aluminum and is 0.05-2.0 millimeters thick.

Preferably, the coating 402 and the overcoating 406 are both electrically conductive and hydrophobic. An exemplary preferred coating 402 is approximately 10 microns thick and comprises sonicated graphite particles in an emulsion, suspension or paint, e.g., graphite particles in an epoxy resin thinned by an organic solvent, such as toluene. A suitable graphite emulsion, Electrodag-423SS, is sold by Acheson Colloids Company, 1600 Washington Ave., P.O. Box 611747, Port Huron, Michigan 48061-1747. An exemplary preferred overcoating 406 comprises exfoliated graphite in the form of sheets of flexible, graphite foil such as those manufactured by UCAR Carbon Company Inc., P.O. Box 94637, Cleveland, Ohio 44101 and sold under the tradename, GRAFOIL®. The graphite foil, GRAFOIL®, is formed from particulate graphite flakes which have been processed through an intercalation process. Although anisotropic and with some degree of ordering, GRAFOIL® is highly electrically conductive and hydrophobic. The thickness of the graphite foil overcoating 406 is 0.05-1.0 millimeters, for example, and preferably 0.5 millimeters.

Referring to FIG. 6B, it can be seen that the overcoating 406 has porosities 410. The coating 402 bonds the overcoating 406 to the bipolar plate 400 and fills the porosities 410.

Referring to FIG. 2, according to the exemplary preferred method 300, the bipolar plate 400 is cleaned at

step 302 and then uniformly painted on both sides with the graphite emulsion 402 at step 304. Next, at step 306, the bipolar plate 400 is positioned between two sheets of graphite foil 406 under a load represented by arrows 412 (FIG. 6B) of 1,500-2,500 pounds applied by a conventional press (not shown) at a temperature of 50-70°C for 30 minutes. At step 308, the bipolar plate 400 is allowed to cool to room temperature under load and is then taken out of the press. At step 310, flow fields 414 (FIG. 6C) are formed, for example, by a stamping operation which results in the deformation of both the graphite foil 406 and the metal plate 400. For the sake of clarity, the porosities 410 are not shown in FIG. 6C. Preferably, the sheets of the graphite foil overcoating 406 have the same shape and basal dimensions as the bipolar plate 400. In an alternative preferred production method, coils or rolls of plate material and graphite foil are fed together through a conventional roll mill or the like, cut to size after they are pressed together by the roll mill and then stamped to form flow fields.

Although the present invention has been described in terms of the preferred embodiment above, numerous modifications and/or additions to the above-described preferred embodiment would be readily apparent to one skilled in the art. It is intended that the scope of the present invention extend to all such modifications and/or additions.

We claim:

1 1. A coated fuel cell bipolar plate comprising:
2 a metal plate including an outer surface;
3 an electrically conductive coating over the outer
4 surface; and
5 an overcoating formed over the coating, the
6 overcoating including graphite.

1 2. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the metal plate is formed with aluminum.

1 3. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the coating is a graphite emulsion.

1 4. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the coating includes graphite particles
3 in an organic suspension

1 5. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating includes exfoliated
3 graphite.

1 6. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating includes porosities that
3 are filled by the coating.

1 7. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating is a foil.

1 8. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating includes particulate

3 graphite flakes which have been processed through an
4 intercalation process.

1 9. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating is electrically
3 conductive.

1 10. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating is hydrophobic.

1 11. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating is anisotropic.

1 12. A coated fuel cell bipolar plate as claimed in
2 claim 1, wherein the overcoating has a thickness
3 approximately between 0.04 and 1.0 millimeters.

1 13. A method of manufacturing a coated bipolar plate
2 for a fuel cell, the method comprising the steps of:
3 providing a metal plate with an outer surface;
4 providing an electrically conductive coating over the
5 outer surface; and
6 providing an overcoating over the coating, the
7 overcoating including graphite.

1 14. A method as claimed in claim 13, wherein the
2 coating is an emulsion, suspension or paint including
3 graphite particles.

1 15. A method as claimed in claim 13, wherein the
2 overcoating includes exfoliated graphite.

1 16. A method as claimed in claim 13, wherein the
2 step of providing the overcoating includes pressing at
3 least one sheet of graphite foil over the coating.

1 17. A method as claimed in claim 16, wherein the
2 metal plate is heated during the pressing step.

1 18. A method as claimed in claim 13, further
2 comprising the step of:
3 forming a flow field on the overcoating.

1 19. A method as claimed in claim 13, further
2 comprising the step of:
3 mechanically deforming the metal plate, the coating
4 and the overcoating to create a flow field.

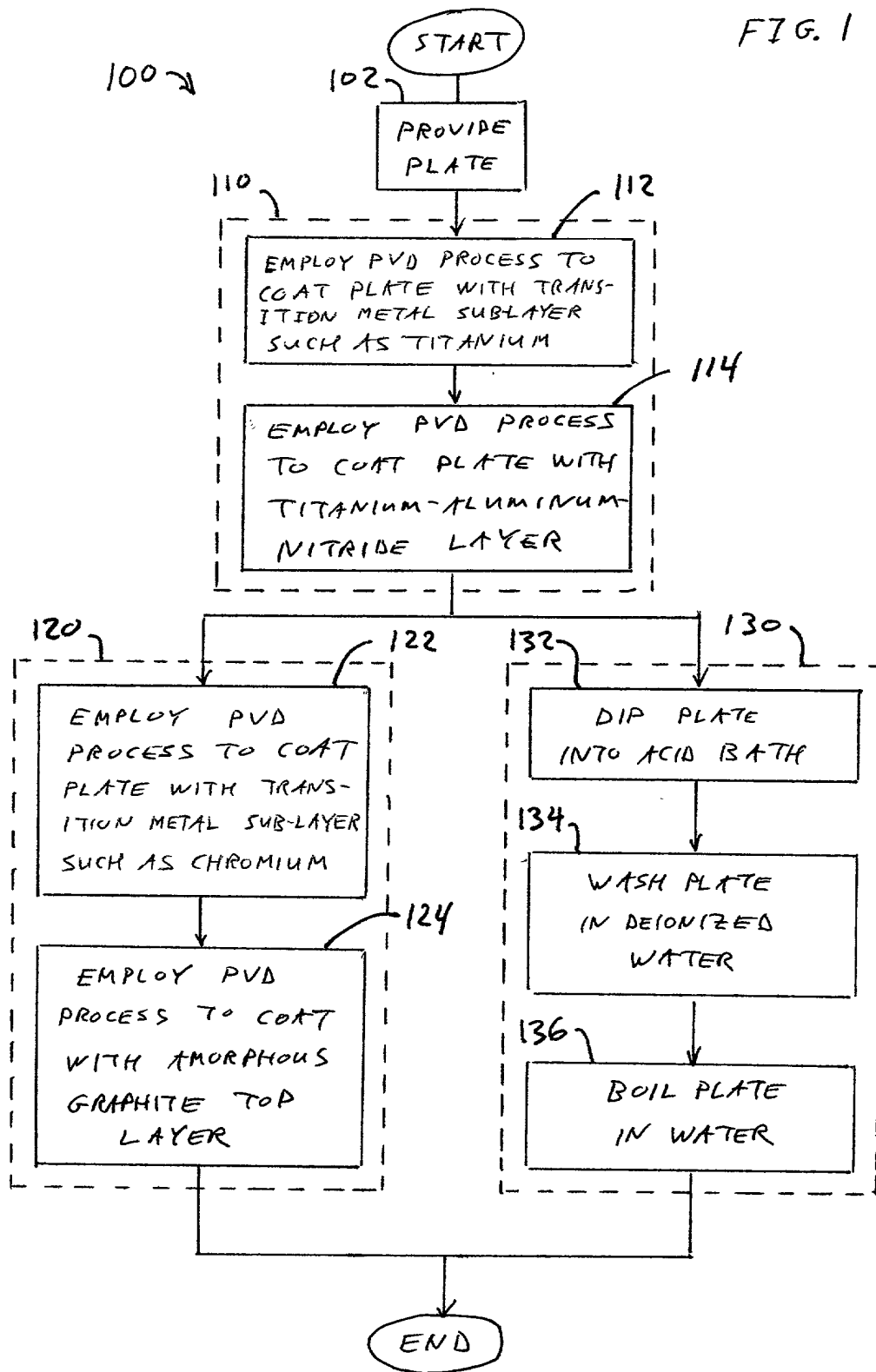
1 20. A method of manufacturing a coated bipolar plate
2 for a fuel cell, the method comprising the steps of:
3 providing a metal plate with an outer surface;
4 providing an electrically conductive coating over the
5 outer surface; and
6 providing an overcoating over the coating, the
7 overcoating being electrically conductive and hydrophobic.

ABSTRACT OF THE DISCLOSURE

A corrosion resistant coated fuel cell plate and method of making the same are embodied in a metal plate
5 provided with a graphite emulsion coating and then a layer
of graphite foil which is pressed over the coating. The
graphite emulsion bonds the graphite foil to the metal
plate and seals fine scale porosities in the graphite
foil. Flow fields are formed by stamping the coated fuel
10 cell plate.

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FIG. 1



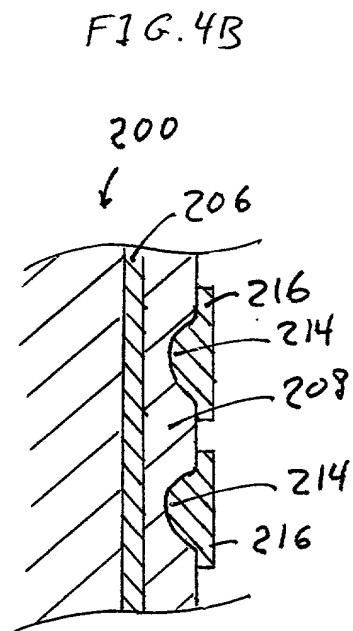
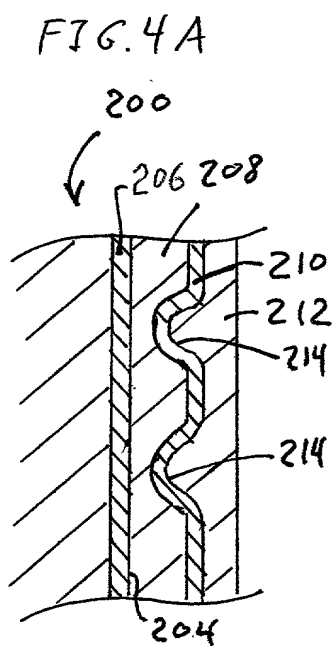
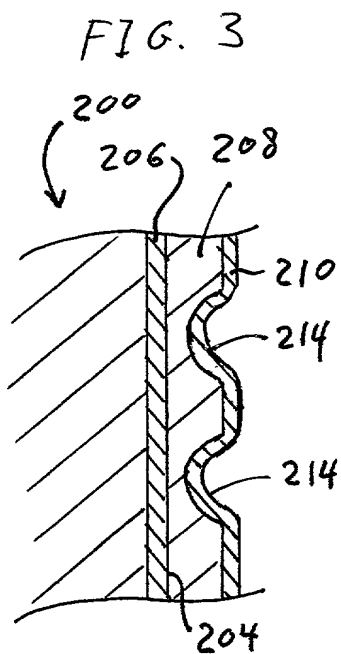
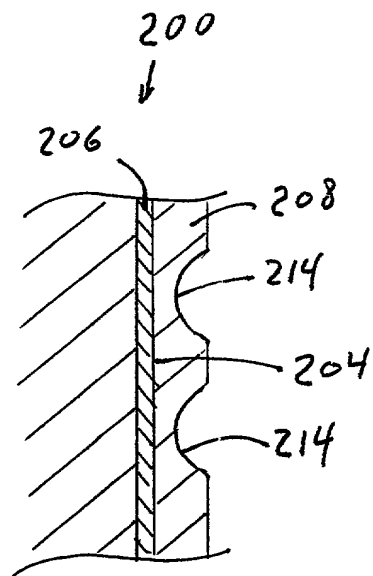
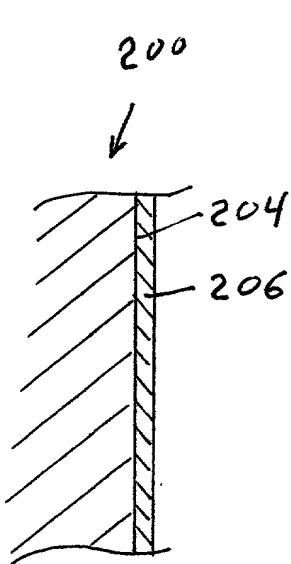
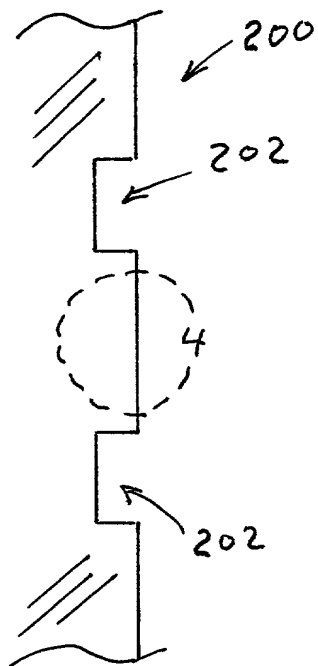


FIG. 4C

FIG. 4D

FIG. 4E

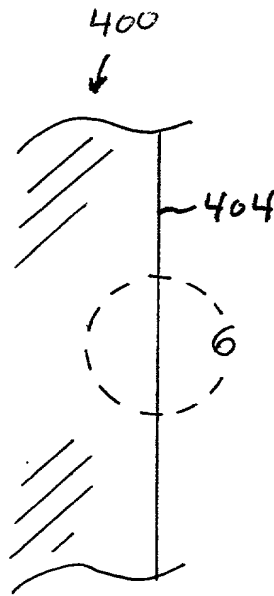
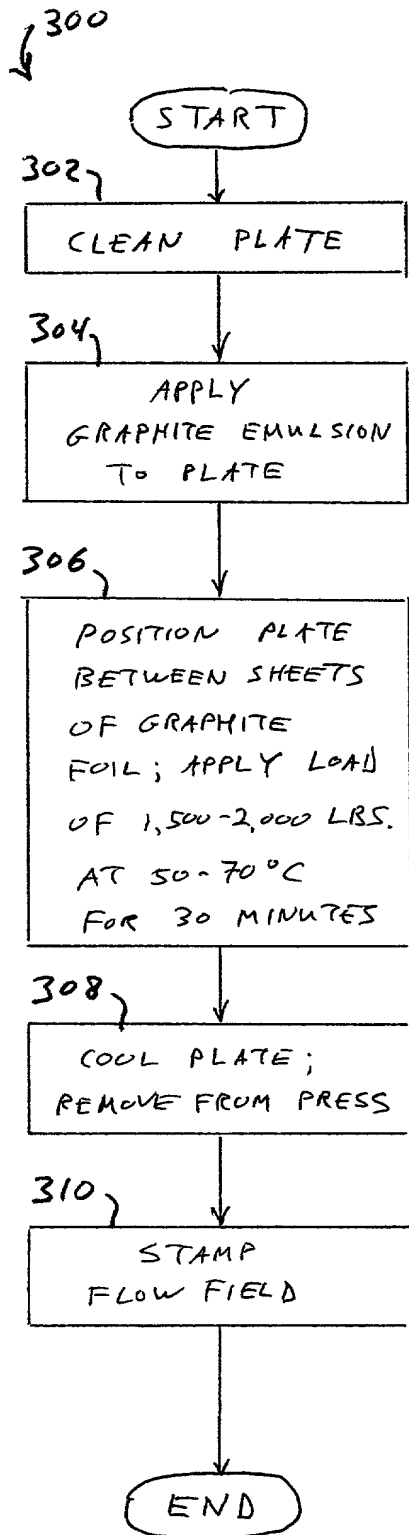


FIG. 5

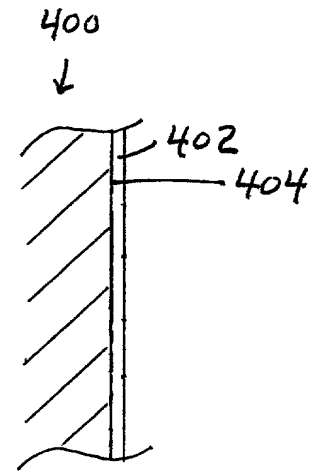


FIG. 6A

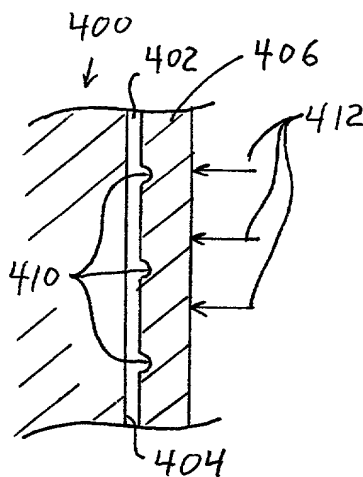


FIG. 6B

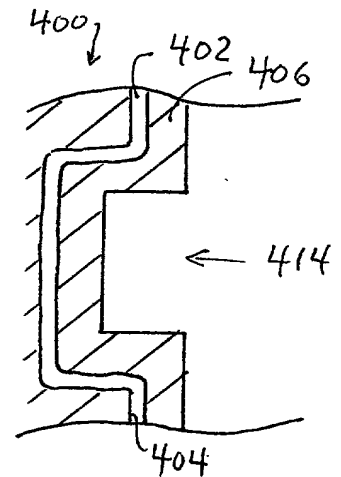


FIG. 6C

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY <small>(Includes Reference to PCT International Applications)</small>	Attorney's Docket Number 050-99-037	U.S. Application No. (if known)
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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Corrosion Resistant Coated Fuel Cell Plate With Graphite Protective Barrier And Method Of Making The Same

the specification of which

☒ is attached hereto

OR

☐ was filed as United States Application Number or PCT International Application Number

on _____

and was amended

on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States, §119 (e) of any United States provisional application(s) listed below.

(Application Number) _____	(Filing Date) _____
(Application Number) _____	(Filing Date) _____

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) or §365 of any foreign application(s) for patent or inventor's certificate or §365 (a) of any PCT international application(s) which designated at least one country other than the United States of America, listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:			
COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)				ATTORNEY'S DOCKET NUMBER 050-99-037	
I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or §365 of any PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:					
PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:					
U.S. APPLICATIONS				STATUS (Check one)	
U.S. APPLICATION NUMBER	U.S. FILING DATE		PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			
POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number) Robert Desmond, Reg. No. 36,430; Larry Palguta, Reg. No. 29,575; Jeanne C. Suchodolski, Reg. No. 34,936; Jerry Holden, Reg. No. 34,182; and Roger H. Criss, Reg. No. 25,570, all attorneys with AlliedSignal Inc., 2525 West 190 th Street, Torrance, California 90504-6099					
Send Correspondence to: AlliedSignal Inc. Law Department-M/S 36-2-76000 2525 West 190 th Street Torrance, California 90504-6099				Direct Telephone Calls to: (name and telephone number) Robert Desmond, Esq. (310) 512-4885	
2001	FULL NAME OF INVENTOR	FAMILY NAME Iqbal	FIRST GIVEN NAME Zafar	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY Morristown	STATE OR FOREIGN COUNTRY New Jersey	COUNTRY OF CITIZENSHIP USA	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 18 Erskine Drive	CITY Morristown	STATE & ZIP CODE/COUNTRY New Jersey, 07960 USA	
202	FULL NAME OF INVENTOR	FAMILY NAME Narasimhan	FIRST GIVEN NAME Dave	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY Flemington	STATE OR FOREIGN COUNTRY New Jersey	COUNTRY OF CITIZENSHIP USA	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 6 Summit Trail	CITY Flemington	STATE & ZIP CODE/COUNTRY New Jersey, 08822 USA	
203	FULL NAME OF INVENTOR	FAMILY NAME Guiheen	FIRST GIVEN NAME James	SECOND GIVEN NAME V.	
	RESIDENCE & CITIZENSHIP	CITY Madison	STATE OR FOREIGN COUNTRY New Jersey	COUNTRY OF CITIZENSHIP USA	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 13 Rosemont Avenue	CITY Madison	STATE & ZIP CODE/COUNTRY New Jersey, 07940 USA	
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.					
SIGNATURE OF INVENTOR 201 <i>John Iqbal</i>		SIGNATURE OF INVENTOR 202 <i>Dan Narasimhan</i>		SIGNATURE OF INVENTOR 203 <i>James V. Guiheen</i>	
DATE 10/5/99		DATE 10/5/99		DATE 10/5/99	

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)				ATTORNEY'S DOCKET NUMBER 050-99-037	
204	FULL NAME OF INVENTOR	FAMILY NAME Rehg	FIRST GIVEN NAME Timothy	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY Rancho Palos Verdes	STATE OR FOREIGN COUNTRY California	COUNTRY OF CITIZENSHIP USA	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 26756 Basswood Avenue	CITY Rancho Palos Verdes	STATE & ZIP CODE/COUNTRY California, 90275 USA	
205	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY	
206	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY	
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SIGNATURE OF INVENTOR 204		SIGNATURE OF INVENTOR 205		SIGNATURE OF INVENTOR 206	
DATE		DATE		DATE	

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY <small>(Includes Reference to PCT International Applications)</small>	Attorney's Docket Number 050-99-037	U.S. Application No. (if known)
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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Corrosion Resistant Coated Fuel Cell Plate With Graphite Protective Barrier And Method Of Making The Same

the specification of which

☒ is attached hereto

OR

☐ was filed as United States Application Number or PCT International Application Number

on _____

and was amended

on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States, §119 (e) of any United States provisional application(s) listed below.

(Application Number) _____	(Filing Date) _____
(Application Number) _____	(Filing Date) _____

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) or §365 of any foreign application(s) for patent or inventor's certificate or §365 (a) of any PCT international application(s) which designated at least one country other than the United States of America, listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:			
COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
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			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)				ATTORNEY'S DOCKET NUMBER 050-99-037	
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PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:					
U.S. APPLICATIONS				STATUS (Check one)	
U.S. APPLICATION NUMBER	U.S. FILING DATE		PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number)

Robert Desmond, Reg. No. 38,430; Larry Palguta, Reg. No. 29,575; Jeanne C. Suchodolski, Reg. No. 34,936; Jerry Holden, Reg. No. 34,182; and Roger H. Criss, Reg. No. 25,570, all attorneys with AlliedSignal Inc., 2525 West 190th Street, Torrance, California 90504-6099

Send Correspondence to: AlliedSignal Inc. Law Department-M/S 36-2-76000 2525 West 190 th Street Torrance, California 90504-6099			Direct Telephone Calls to: (name and telephone number) Robert Desmond, Esq. (310) 512-4885		
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204	FULL NAME OF INVENTOR	FAMILY NAME Iqbal	FIRST GIVEN NAME Zafar	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Morristown	STATE OR FOREIGN COUNTRY New Jersey	COUNTRY OF CITIZENSHIP USA
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 18 Erskine Drive	CITY Morristown	STATE & ZIP CODE/COUNTRY New Jersey, 07960 USA
202	FULL NAME OF INVENTOR	FAMILY NAME Narasimhan	FIRST GIVEN NAME Dave	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Flemington	STATE OR FOREIGN COUNTRY New Jersey	COUNTRY OF CITIZENSHIP USA
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 6 Summit Trail	CITY Flemington	STATE & ZIP CODE/COUNTRY New Jersey, 08822 USA
203	FULL NAME OF INVENTOR	FAMILY NAME Guiheen	FIRST GIVEN NAME James	SECOND GIVEN NAME V.
	RESIDENCE & CITIZENSHIP	CITY Madison	STATE OR FOREIGN COUNTRY New Jersey	COUNTRY OF CITIZENSHIP USA
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 13 Rosemont Avenue	CITY Madison	STATE & ZIP CODE/COUNTRY New Jersey, 07940 USA

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE	DATE	DATE

Combined Declaration For Patent Application and Power of Attorney (Continued) (Includes Reference to PCT International Applications)				ATTORNEY'S DOCKET NUMBER 050-99-037	
2 0 4	FULL NAME OF INVENTOR	FAMILY NAME Rehg	FIRST GIVEN NAME Timothy	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY Rancho Palos Verdes	STATE OR FOREIGN COUNTRY California	COUNTRY OF CITIZENSHIP USA	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 26756 Basswood Avenue	CITY Rancho Palos Verdes	STATE & ZIP CODE/COUNTRY California, 90275 USA	
2 0 5	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY	
2 0 6	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY	
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SIGNATURE OF INVENTOR 204 <i>Timothy J. Rehg</i>		SIGNATURE OF INVENTOR 205		SIGNATURE OF INVENTOR 206	
DATE 10/5/99		DATE		DATE	